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Monitoring-Based Commissioning
with Advanced EMIS Analysis

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Presentation *Overview*

1. Monitoring Based Commissioning Objective
2. Definition of Monitoring-Based Commissioning (MBCx)
3. MBCx – Value Added Proposal
4. MBCx and EMIS
5. EMIS Functions
6. MBCx – Building Level Analysis
7. MBCx – System Level Analysis
8. Case Study 1 – Carson Graham Secondary
9. Case Study 2 – Abbotsford Collegiate

MBCx Objectives

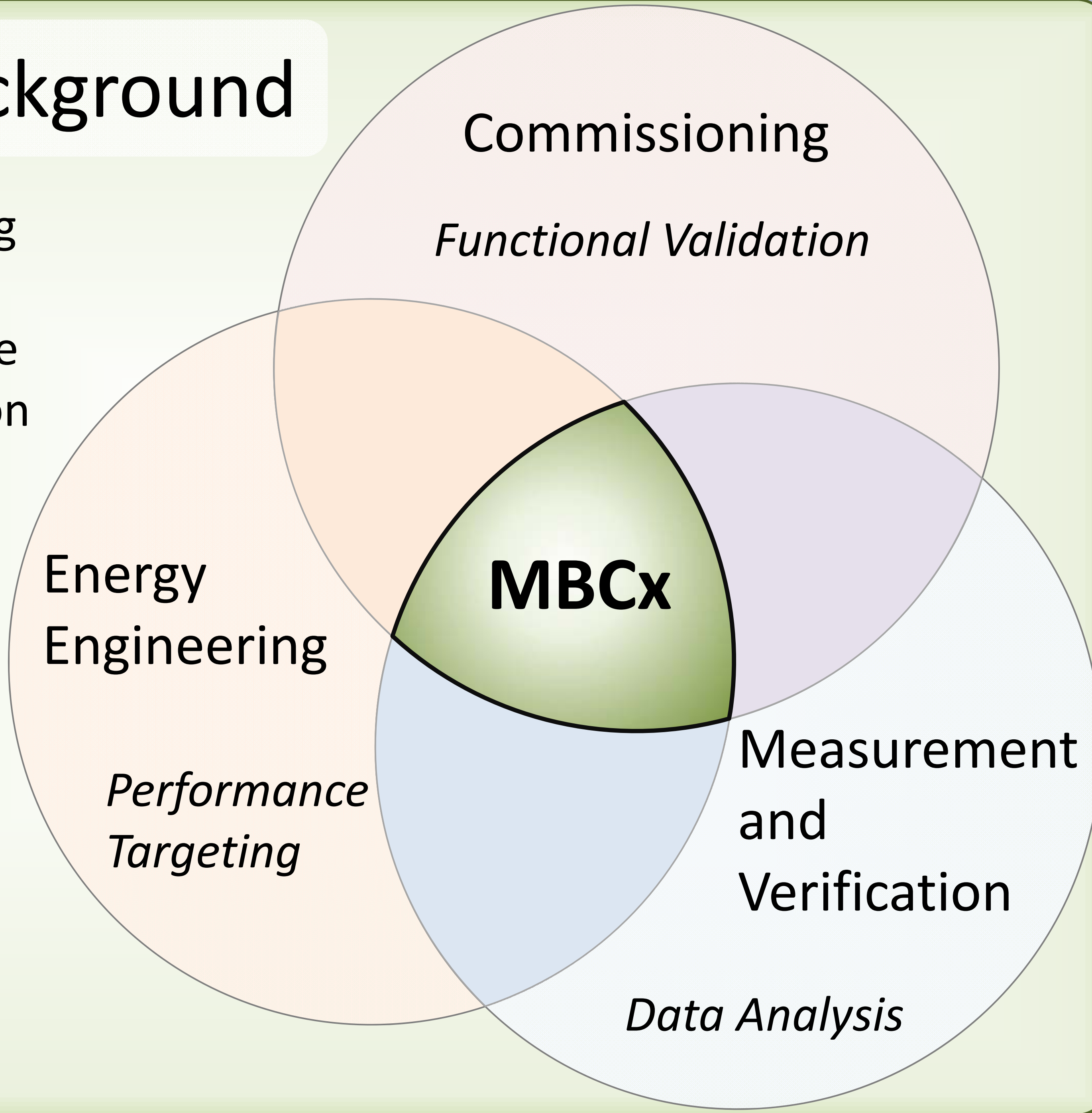
1. Building systems optimized performance
2. Persistent savings
3. Empowering building and facility operators with knowledge and tools to effectively manage O&M process.

Is your building running optimal?

What does this mean?

MBCx Background

- Commissioning supported by comprehensive data acquisition and analysis
- A holistic process for optimizing building performance



MBCx - Value Added Proposal

Conventional Design, Construction, Operation process:

Consultant Designed → ***Contractor Built/Configured*** → ***Owner Operated***

Specifications
Performance Goals not Identified

No Systems Manuals
Lost "Knowledge"

- Facility operators are detached from energy and performance operation targets.

MBCx - Value Added Proposal

Goals of MBCx

1. Clarify and document building operational intent for ideal performance – systems manuals
2. Engage building operators and identify and correct operational issues
3. Configure systems operation for maximum energy performance
4. Quantify performance through relevant metrics and Key Performance Indicators (KPI)
5. Implement the tools and systems necessary to track and maintain performance

MBCx - Value Added Proposal

Conventional O&M	*MBCx*
Reactive O&M through occupant complaints and DDC alarms	*Proactive* O&M through observing and tracking performance metrics
Understanding of systems operation through trial-and-error and equipment failures	Documented best practises and systems performance parameters via systems manuals.
Unknown facility performance and lack of clear targets and performance goals	Set targets, set performance goals and measured performance.

MBCx and EMIS

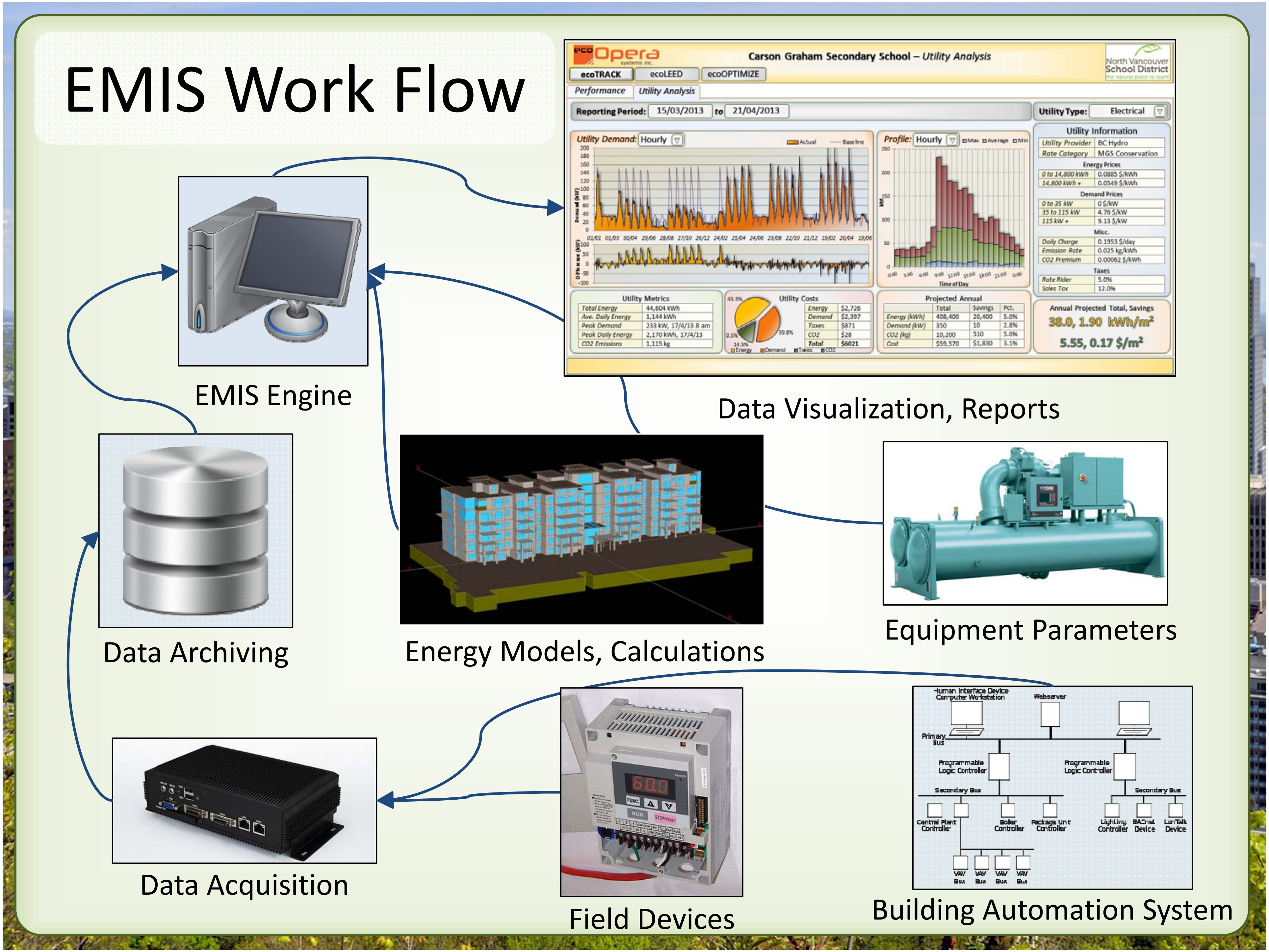
- The cornerstone of MBCx is a comprehensive Energy Management Information System (EMIS)

An EMIS is an analytical engine with capabilities above and beyond that of a BAS. Capabilities include up to:

- Utility cost and billing analysis
- Enhanced graphical presentations – cusum, control charts, scatter plots, enhanced trend logs
- Statistical analysis for energy or operational parameter historical benchmarking and forecasting
- Remote database access for weather data or building energy
- Advanced energy calculations – equipment/system KPIs, energy simulations

EMIS Functions

Analysis-Type	Building Level	Systems Level
Data Collected	• Total electrical energy • Total gas energy • District energy meters	• Energy sub-meters • Thermal/Btu meters • BAS Data points – equipment status, speed, temperature, flow, position, etc.
Analysis Conducted	• Primary energy benchmarking • Measurement and verification of savings • Energy trending (daily, weekly, monthly profiles)	• Full energy end-use breakdown • Equipment performance – efficiency, run-times, cycling, average operating conditions • Systems faults
Pros/Cons	• Relatively inexpensive • Easy quality control • Cannot directly uncover optimization opportunities • Limited insight into building operation	• Full operation visibility • All key optimization opportunities can be identified • Sub-meters add cost • Data quality management • Limited EMIS vendors



Proceedings of the 13th International Conference for Enhanced Building Operations, Montreal, Quebec, October 8-11, 2013

MBCx Findings

HVAC Systems Faults

- Over-enabling/unoccupied run-time
- Deficient pressure/fan speed reset
- Sub-optimal SAT reset
- Over or under-ventilation
- Simultaneous heating and cooling
- Faulty, disconnected zone sensors
- Spaces under-heated or cooled

HVAC Plant Faults

- Equipment rapid cycling
- Sub-optimal equipment sequencing
- Lack of or deficient SWT reset
- Lack of pressure/pump speed reset
- Pump over-enabling

Lighting Faults

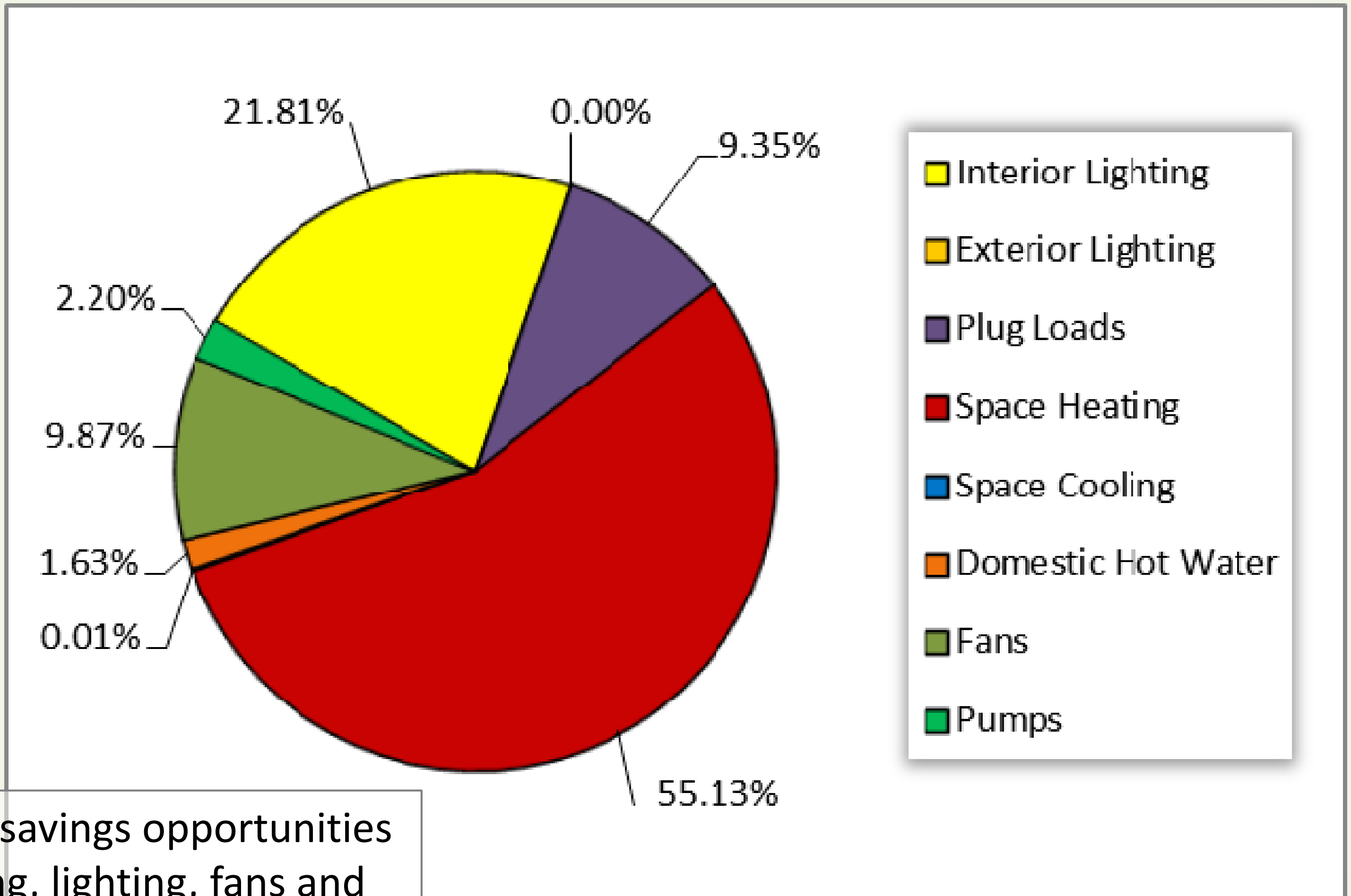
- Excessive unoccupied use
- Unresponsive occupancy sensor switching
- Faulty photocells

➢ Complex systems give rise to more points of failure

➢ Occupant comfort may be maintained while faults persist, wasting $$$

MBCx – Preliminary Analysis

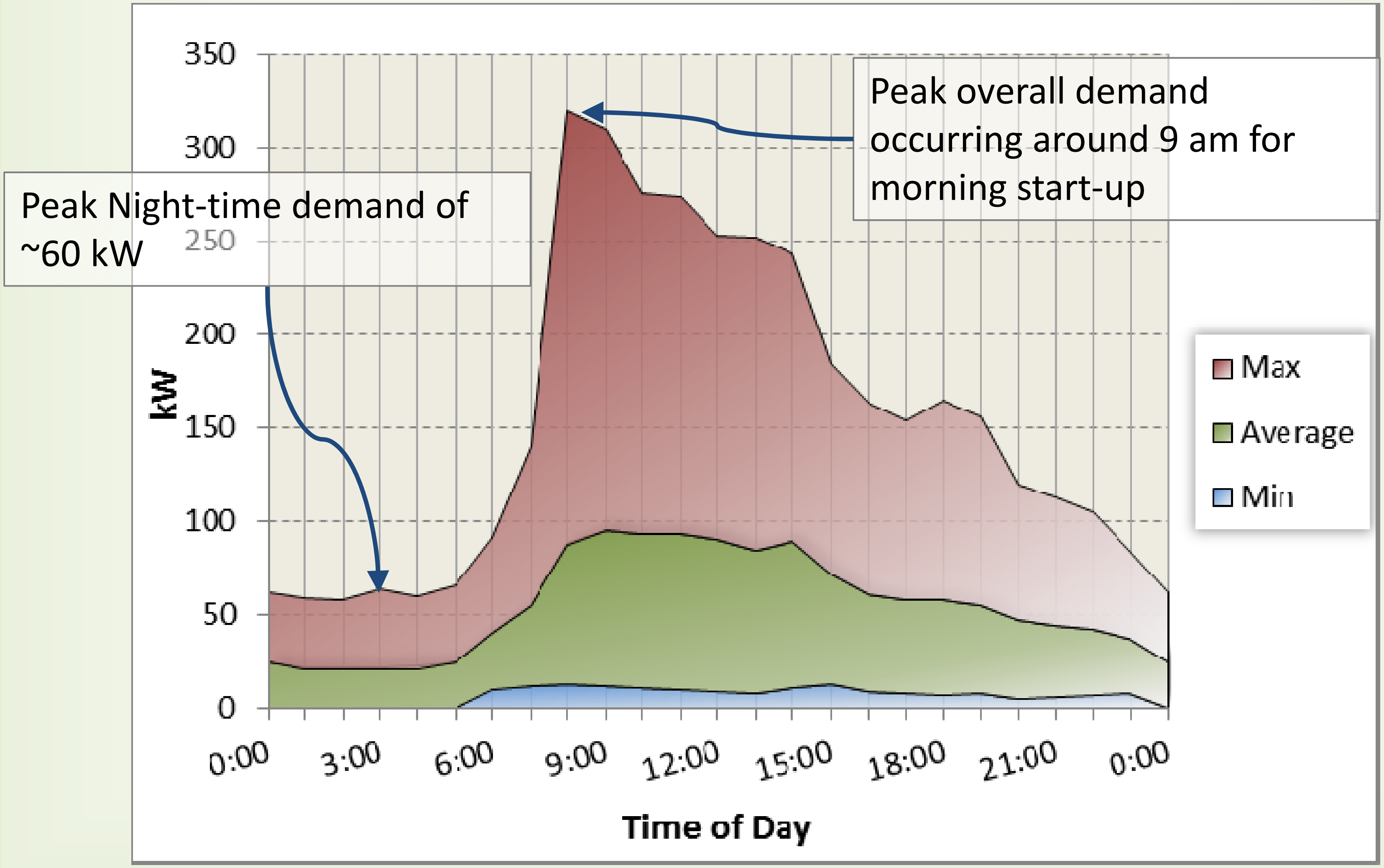
Energy Use Trends – Energy Breakdown



Primary savings opportunities in heating, lighting, fans and plug loads

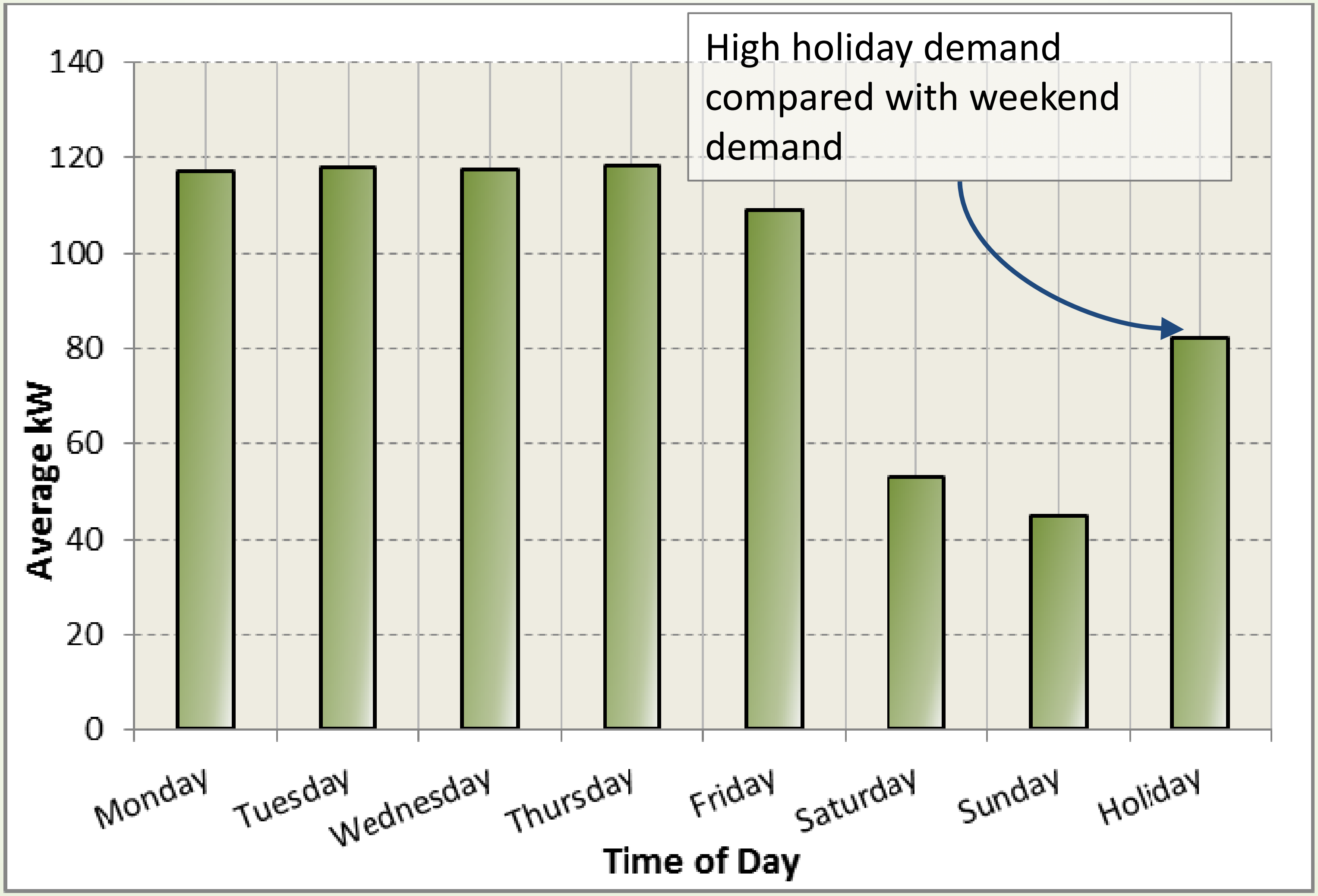
MBCx – Building Level Analysis

Energy Use Trends



MBCx – Building Level Analysis

Energy Use Trends – Weekly Profiles



MBCx – Building Level Analysis

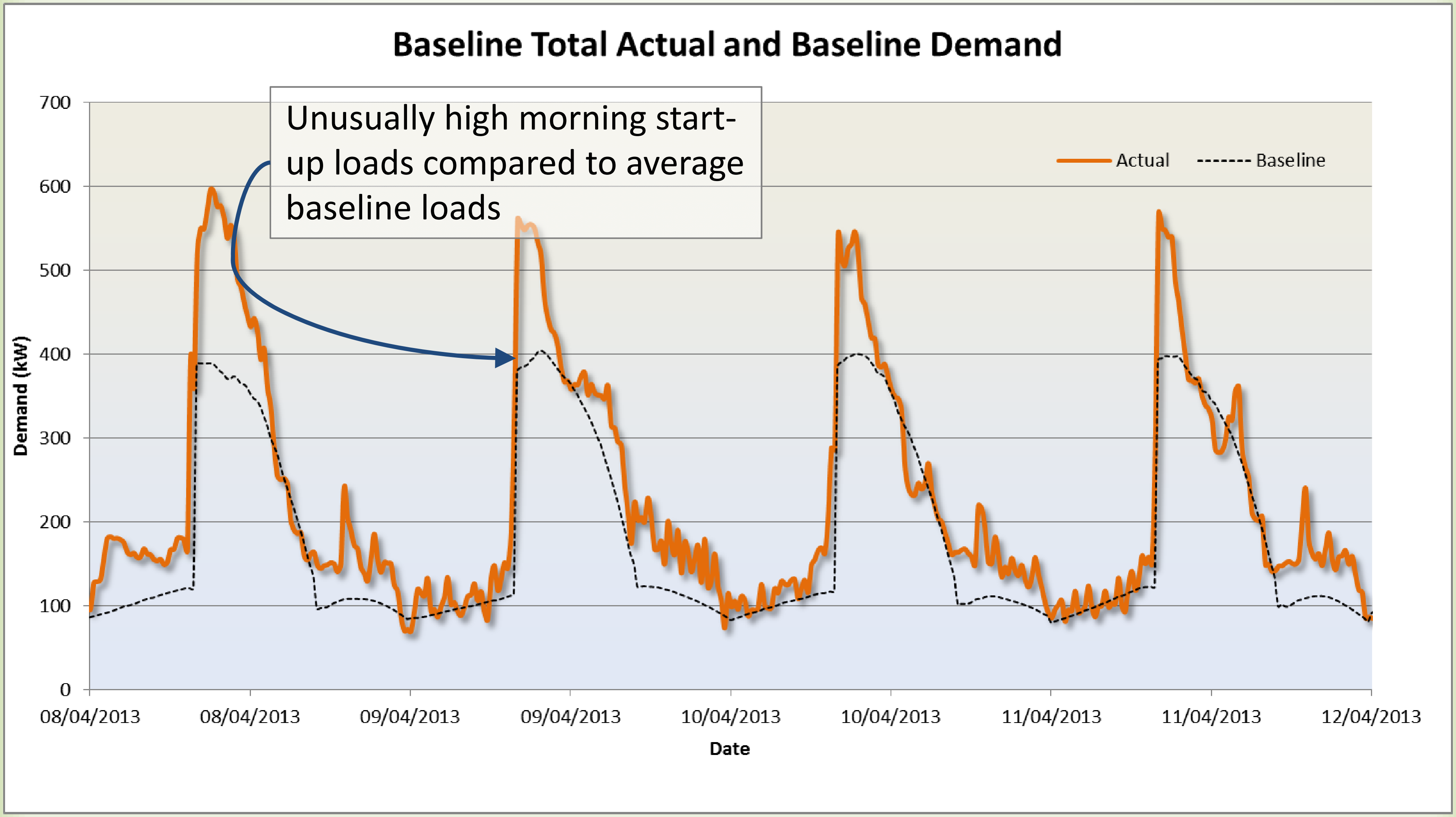
Utility Metrics

Total Building Electrical Summary	
Energy Consumption (kWh)	67,302
Peak Demand (kW)	269
Peak Demand Time	06/06/2013 11:30
Average Daily Energy Use (kWh)	8896
Peak Daily Energy Use (kWh)	13,198
Peak Energy Use Day	06/06/2013
Unoccupied Consumption (kWh)	38,563
Unoccupied Consumption %	57%
Peak Unoccupied Load (kW)	189
Peak Unoccupied Load Time	28/06/2013 14:15

Unoccupied consumption 57% energy of total energy for this period!

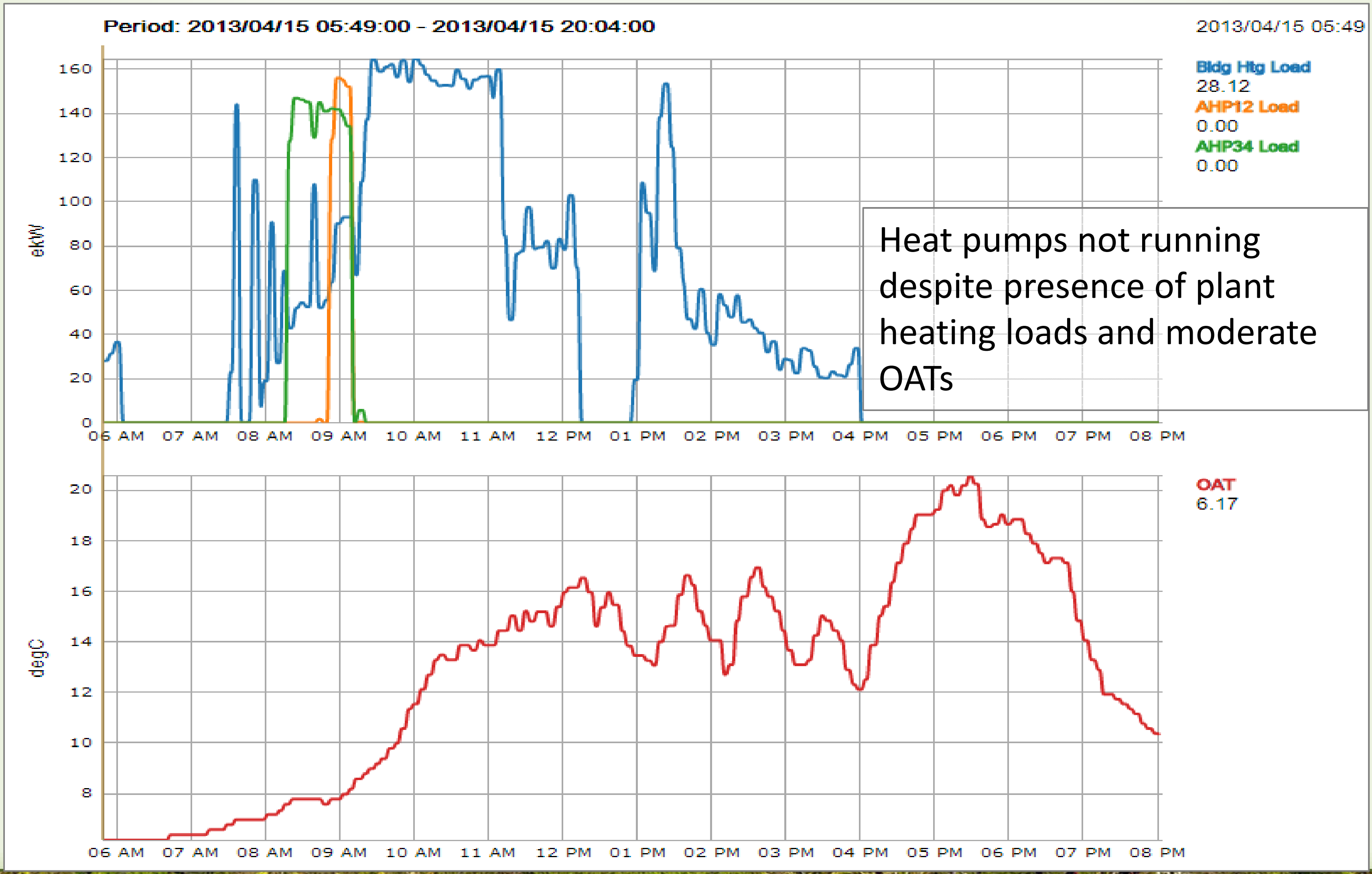
MBCx – Building Level Analysis

Energy Benchmarks



MBCx – System Level Analysis

Detailed Trend Logs



Heat pumps not running despite presence of plant heating loads and moderate OATs

MBCx – Systems Level Analysis

Equipment Operational Characteristics

Pumps	Service	Run-Time (hrs)	# Cycles	Average Run Speed	Average Flow Rate (L/s)	Average Design Flow Fraction	Elec Energy (MWh)	Pump EIR kWh/(m^3x10^3)	Unloaded Energy %
P1	B1	196	38	N/A	7.79	95%	0.23	0.04	14%
P2	B2	195	43	N/A	7.74	94%	0.22	0.04	15%
P3	HtgSys	165	26	97%	1.52	6%	0.39	0.43	8%
P4	HtgSys	165	32	97%	2.27	9%	0.39	0.29	14%
P5	ClgSys	0	0	0%	0.00	0%	0.00	0.00	0%
P6	ClgSys	57	18	90%	0.76	20%	0.10	0.65	90%
P7	AHP1&2	93	42	97%	3.61	56%	0.13	0.10	3%
P8	AHP3&4	100	43	97%	3.63	56%	0.15	0.11	2%
P9	HtgAWing	330	55	98%	2.86	72%	0.44	0.13	21%

Unusually high speeds relative to flows – VFDs are not modulating

MBCx – System Level Analysis

Plant Performance Metrics

Utility Summary	
Electricity Use (MWh)	0.56
Natural Gas Use (MWh)	46.54
Pump Elec Use (MWh)	1.32
Peak Electrical Load (MW)	110.56
Plant Run Cost	$1,563

Performance Summary	
Equipment Efficiency (COP)	0.92
Total Efficiency (COP)	0.90
Cost Performance ($/MWh-Load)	35.89

Performance Targets	
Equipment Efficiency (COP)	2.93
Total Efficiency (COP)	2.74
Cost Performance ($/MWh-Load)	25.50

Operating Characteristics	
Plant Thermal Energy (MWh)	43.5
Average Thermal Load (kW)	93.3
Peak Thermal Load (kW)	510.5
Run-Time (Hrs)	303.25
Average SWT (°C)	58.22
Average dT (°C)	3.67
Peak Load % Design	32%
Average SWT % Design	95%
Average dT % Design	17%
Average Plant Loading	6%
Average Equip Loading	23%

Low peak and average loads, yet SWT is near the design value. Overall efficiency is low compared with design efficiency.

Case Study 1

Carson Graham Secondary School

Performance Features

- 9,300 m^2, targeting LEED Gold
- High performance envelope
- BAS-integrated lighting with occ-sensor and photocell control
- VAV Energy-Recovery-Ventilators with VFDs and occ-sensor enabling
- Reversible ASHPs with condensing boiler backup and VFD pumping

Deficiencies Identified

- Systems over-enabling
- Deficient air system pressure reset
- ASHPs greatly under-utilized
- No HW temperature reset
- VFD pumps at 100% continuously
- Pump false-starting
- MUA continuous operation

Performance Metrics	
Baseline Projected EUI*	97
NRCan Database EUI	180
Proposed Energy Model EUI	82
Reference Energy Model EUI	121
Energy Savings through Optimization	**15%**

*kWh/m2/year

Case Study 2

Abbotsford Senior Secondary

Performance Features

- 10,700 m^2, targeting LEED Gold
- Extensive lighting controls via occ-sensors and photocells
- VAV Energy-Recovery-Ventilators with VFDs and occ-sensor enabling
- WSHPs served by an reservoir with condensing boiler backup
- Distributed water-loop heat-pumps

Deficiencies Identified

- Systems over-enabling
- Deficient hydronic pressure reset
- Deficient SWT reset
- Pumps enabled continuously
- Continuous exhaust fan operation
- Over-ventilation by a number of WLHP units

Performance Metrics	
Baseline Projected EUI*	89
NRCan Database EUI	180
Proposed Model EUI	79
Reference Model EUI	128
Energy Savings through Optimization	**11%**

*kWh/m2/year

MBCx with Advanced EMIS Analysis

Thank You!

Questions?